REPORT

TO

THE RIGHT HON. THE SECRETARY OF STATE FOR THE HOME DEPARTMENT

ON THE

CIRCUMSTANCES ATTENDING TWO EXPLOSIONS

WHICH OCCURRED ON THE

UNDERGROUND RAILWAY, LONDON,

On the 30th October 1883;

BY

COLONEL V. D. MAJENDIE, C.B.,

H.M. CHIEF INSPECTOR OF EXPLOSIVES;

AND

CAPTAIN J. P. CUNDILL, R.A.,

H.M. INSPECTOR OF EXPLOSIVES.

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No. LV.

REPORT

TO

THE RIGHT HON. THE SECRETARY OF STATE FOR THE HOME DEPARTMENT

ON

The Circumstances attending Two Explosions which occurred on the Underground Railway, London, on the 30th October 1883;

BY

COLONEL V. D. MAJENDIE, C.B.,

H.M. CHIEF INSPECTOR OF EXPLOSIVES;

AND

CAPTAIN J. P. CUNDILL, R.A.,

H.M. INSPECTOR OF EXPLOSIVES.

SIR, Home Office, 17th November 1883.

WE have the honour to report that, in obedience to your Order (Home Office Papers, $\frac{A\ 32018}{5}$), made under the 66th section of the Explosives Act, 1875, we have held an inquiry into the causes of, and the circumstances attending two explosions which occurred in London, on the Underground Railway, on the evening of the 30th October 1883.

In accordance with the provisions of the above-mentioned section of the Act we beg to furnish the following Report:—

Where and when explosions occurred.

The first of these explosions occurred about 7.52 p.m. in a tunnel near the Praed Street station of the Metropolitan Railway; the second explosion occurred shortly after 8 p.m. in a tunnel between the Charing Cross and Westminster stations of the District Railway.

Fortunately neither of the explosions was attended with loss of life, but, in the case of the Praed Street explosion, 62 persons sustained injury (generally of an inconsiderable character) from cuts and bruises.

It will probably be convenient if we relate the circumstances connected with the two explosions respectively, and then proceed to consider the character of the explosive agent employed, and the conditions under which, as we believe, the explosions were effected.

A.—*Explosion near Praed Street Station.*

Praed Street explosion.

This explosion took place at about 7.52 p.m., as the "up" Metropolitan train, which had left the Mansion House at 7.10 p.m., was travelling from Praed Street towards the Edgware Road station. This train was due at Praed Street at 7.46, but it was four minutes late, and the lapse of another minute at Praed Street would make the actual time of the train leaving that station, as nearly as can be ascertained, 7.51 p.m.

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The train was made up as follows :—*

Immediately beyond Praed Street the line passes through a small open cutting (17 feet long), when it enters a short (177½ feet) tunnel†, after which is another short open cutting (138 feet long), which is succeeded by a second tunnel, 483 feet long.‡

Position of train at moment of explosion.

The train, travelling at a pace estimated at from eight to nine miles per hour, had arrived at the position shown on Plate I., when an explosion occurred at the spot marked on that plate. At this moment the engine and the front portion of the second-class carriage were within the second tunnel, the remainder of this second-class carriage, the whole of the composite and first-class carriages, and about half the leading third-class carriage were in the open, while the hinder portion of the leading third-class carriage and the whole of the two hinder third-class carriages were in the first or shorter tunnel, the front part of the rear third-class carriage being exactly opposite the seat of the explosion, which took place between this carriage and the wall.

Means by which exact position of train at moment of explosion can be determined.

It is quite easy to fix the exact position of the train at the moment of the explosion. Thus, (*a*) the seat of the explosion is shown, as will presently be more particularly explained, by a crater, at the spot marked on the plan (distant about 138 feet from the station); (*b*) the fact that the front portion of the rear third-class carriage was directly opposite to the seat of the explosion is indicated in the clearest possible manner by the character of the damage (to be hereafter described) sustained by this and the other carriages, and radiating from a centre opposite to this portion of the rear third-class carriage.§

The position of the train at the moment of explosion being thus fixed, we find that it would be reached in about one minute after leaving Praed Street, *i.e.*, at 7.52 p.m.

The effects of the explosion were as follows:—

Injury to station and neighbouring houses.

A considerable quantity of glass was broken in Praed Street station (including four large plate-glass windows on the gallery front of the refreshment room), in the houses along the open cutting beyond the first tunnel, and in the houses which crossed the cutting at the second tunnel.‖ Moreover, all the gas was extinguished, but, as no fittings were injured, it was speedily relit.

Damage to tunnel and fittings.

The damage in the tunnel consisted of a vertical crater in the wall about 12 inches high, 13 inches wide, and 4 inches to 6 inches deep. Immediately below this crater, and extending about 15 inches along the wall, was a horizontal crater about 6 inches deep, partly in the ballast and partly in the brick footing of the tunnel (see Plate II.) The flinty ballast in this crater was considerably splintered, and the brick footing pulverised. A 2-inch iron gas pipe ran along the wall at a height of 10 inches; a length of this, measuring 14 feet, was blown away, one end being much torn and twisted, and the whole piece bent into the form of a bow. At a distance of 15 inches from the wall, and parallel with it, was an iron switch rod, consisting of 1¼-inch gas pipe, supported on iron rollers at the level of the rails, from which it was distant 2 feet 9 inches, the rollers being fixed on a wooden plank laid on the ballast. This board had about 4 feet of its length blown to splinters, and a large piece was thrown on to the rail, and some of the wheels of the train passed over it. A length of the switch rod, measuring about 2 feet, and

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* The length of each carriage of the train, including buffers, was 43 feet; the length of the engine was 33 feet; consequently, the total length of the train was $43 \times 6 + 33 = 291$ feet.

† See Plate II. for section of this tunnel. ‡ See Plate I.

§ The tops of some of the carriages were covered with broken window glass, while others were free from glass. This glass was from the windows of the houses which occupy one side of the cutting between the two tunnels, and from a house, which is built across the line at the entrance of the second tunnel. Thus a further means is afforded of determining when carriages were under cover and which were in the open at the time when the shower of shattered glass descended upon the train, due allowance being made for the time occupied by the wave of explosion in reaching the windows, and for the time occupied by the falling glass relatively to the forward movement of the train.

‖ Details of the injury done in station are given in Appendix A.

corresponding exactly with the portion of the gas pipe which sustained the maximum injury, was blown out, the central part of this detached portion being split up and torn. This piece of switch rod also bore marks of the passage of wheels over it.

A telegraph cable, carrying the signalling wires, ran along the wall of the tunnel at a height of about $8\frac{1}{2}$ feet. These wires were cut by the explosion.

The walls of the tunnel exhibited some radiating scores, due to sharp débris blown against them, and the end of a sleeper opposite to the crater, but partially protected by the ballast in which it was embedded, had a number of pieces of splintered flint deeply driven into it. The rails were entirely uninjured, and the only other noticeable effect in the tunnel was the scouring of the walls and roof on the down side, due doubtless to the rush of gas over the train and the resulting violent compression of the air on that side of the tunnel.

Injury to train.

The engine and the two leading carriages of the train sustained no injury, and the first-class carriage escaped with the fracture of two broken door windows and a panel.

The front third-class carriage (see Plate I., "*a*") had two partitions, three end panels, four quarter-lights, and two gas reflectors broken.

The two rear third-class carriages ("*b*" and "*c*") sustained very considerable damage, the greater part of the glass being broken into small fragments, panels and partitions shattered, the roofs and floors disturbed, and the footboards broken. Moreover, in the case of the hinder carriage ("*c*") the front iron hanger of the top footboard was broken off, and two other hangers were bent. In fact these two carriages exhibited an appearance of more or less complete wreckage, though owing to their strength of construction no part of the framing or running gear was injured. The gas was extinguished throughout the train, and in the case of the two rear carriages the gas had escaped from the reservoirs; but we ascertained experimentally that no part of the gas apparatus was injured.* It is worthy of notice that the injury to the train was not limited to the side on which the explosion occurred, but extended to the right or reverse side. Indeed, in the case of the first third-class carriage (*a*) the damage was most marked on the reverse side.†

A careful examination showed unmistakeably which portion of the train was opposite to the charge at the moment of explosion, viz., (as has been already stated) the front part of the rear third-class carriage. This was indicated not only by the greater damage wrought on this portion of the train, as exhibited by the two broken footboards, the broken and bent footboard hangers, and by the generally more destructive character of the injury at this point, but also by the fact that the explosive had evidently operated with considerable force on the back end of the carriage next in front ("*b*"), which had been blown in, while the front end of the last carriage ("*c*") had also been blown inwards (*i.e.*, backwards), an effect which may be ascribed to the rush of gas into the space between the two carriages. The lamp between these two carriages was also blown away. The back end of the top footboard of the last carriage but one was also broken off upwards. Other indications of the exact position of the train in relation to the exploded charge were furnished by certain scratches or marks on the panels of the last carriage but one, radiating from a point of which a crater opposite to the front portion of the rear carriage would be the centre; while the general distribution and character of the injury sustained by the train as a whole, and the two last carriages in particular, furnished further indications of a force operating with diminishing effect in both directions from a crater situated as above described.

The deeply pitted condition of the under sides of the footboards in this portion of the train, due to a number of sharp fragments, chiefly of ballast, but in several instances of copper, which had been forcibly driven into and

* In the case of all the carriages, except the two hind third-class carriages, the reservoirs contained gas, and we found that the lamps could all be lighted; in the case of the two hind third-class carriages we found on filling them with gas that they were uninjured, and that the burners could be at once lit.

† For details of the damage done to train see Appendix B.

against them, showed, if further proof were needed, that the force had acted immediately under them; besides possessing a special significance which will call for further comment hereafter.

Lastly, it may he well to notice here that there were exhibited on the left panels and under side of the train, for about half the length of the first-class carriage, a number of white splashes or flecks, which continued, although in diminishing quantity, along the two foremost third-class carriages. These splashes will hereafter suggest some important observations.

Injury to persons.

As already stated, 62 persons* (chiefly passengers in the third-class carriages) were injured by cuts and contusions from the pieces of glass and débris, and in one or two cases by fracture of the drum of the ear and by severe shocks. Five of the injured persons were and are still under treatment in St. Mary's Hospital, the others were able (after treatment at the hospital and locally) to return to their homes.

Character of explosion.

The explosion is described as having been of a very powerful description, and was preceded for an appreciable interval of time, according to the accounts of several witnesses, by a light of peculiar brightness.† In one case, and in one only, is any mention made of more than one explosion; but Mr. W. Langridge, a passenger in the first-class carriage of the injured train, speaks very positively to an explosion like that of a fog-signal a short time before the main explosion. Although one effect of the explosion was to cut the gas pipe, and so extinguish the signals, the driver very judiciously and properly did not stop, but proceeded steadily to Edgware Road station, where the injured passengers were attended to. This conduct on the part of the driver probably averted a disaster of a much more serious character, for had the train been stopped, there can be no doubt that many of the excited passengers would have got out, and as a down train was almost immediately due, they would have incurred grave risk of being run over.‡

B.—*Explosion in Tunnel between Charing Cross and Westminster.*

Charing Cross explosion.

This explosion took place between 8 and 8.5 p.m.§ in the tunnel of the District Railway between Charing Cross and Westminster. The spot may be roughly described as about one-third of the distance from the former station, having been about 241 yards from Charing Cross and about 488 yards from Westminster (see Plates III. and IV.) Fortunately in this case no train was passing at the time, and the damage done was of an insignificant character, having been limited to the extinction of a number of gas lamps in the Charing Cross and Westminster stations and in the trains which were in these stations at the time; to the breaking of some glass at both the above-named stations;‖ to the injuring in the tunnel of about 60 yards of telegraph cables and telephone wires, and the wood casing containing the latter; to the formation of a crater in the ballast, measuring about $3' \times 4'$ and $1'$ deep; and to the "pitting" of the walls of the tunnel for some little distance to the right and left of the crater, and for a somewhat greater distance on the opposite side. The position of the crater of course accurately marks the seat of the charge, and on reference to Plate IV. it will be seen that this point was to the south of the "up" line, and between it and one of the bays of the tunnel wall. To the circumstance that the explosion took place opposite a bay, and therefore not in contact with any brickwork, is to be attributed the escape of the walls of the tunnel from any injury beyond the superficial

Extent of damage.

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* This is the number given by the manager of the Metropolitan Railway. But it is possible that there were other cases of slight injury of which no record was obtained.

† Evidence of Stephen Harris (engine-driver), William Smith (guard), Joseph Double (station inspector at Praed Street), Robert Neves (bookstall attendant, Praed Street), W. J. Langridge (passenger in first-class carriage), Jas. Turner (passenger in the middle third-class carriage), Corporal Warren (passenger in the middle third-class carriage).

‡ As a matter of fact, a down train passed almost immediately after the explosion.

§ One witness, the driver of an up train, which was standing at Westminster at the moment of the explosion, fixes the explosion at about 8.5½ p.m. The guard of an up train, which was moving into Charing Cross at the moment of the explosion, fixes it about 8.5 p.m. The guard of the up train, which was just leaving Westminster, and the Westminster station-master fix it at about 8.4 p.m.

‖ See Appendix C.

scratching and pitting by the projected débris. The rails were entirely uninjured, but the ends of two sleepers close to which the explosion occurred had sustained some injury.

Position of trains at moment of explosion.

Up trains.

At the moment of the explosion the up train, timed to leave the Mansion House at 7.53, which was running three minutes late, had just been signalled out of Westminster station, and was in the act of leaving (about 8.4 p.m.) This train had left Charing Cross about $2\frac{1}{2}$ minutes previously, and therefore must have passed the spot where the explosion occurred between one and two minutes before it took place. Another up train, timed to leave the Mansion House 7.56 p.m., but running four minutes late, was in the act of drawing into Charing Cross station when the explosion occurred. This train would in the ordinary course of working have reached the scene of the explosion in about another minute. But on the explosion occurring the traffic was stopped on the up line, and this train did not go forward for about $1\frac{3}{4}$ hours.

Down trains.

The last down train to pass through the tunnel before the explosion was an Inner Circle one, due at Charing Cross at 7.58, and running about five minutes late. This train had just left Charing Cross when the explosion occurred. No one in this train had any knowledge of anything unusual having happened until they arrived at the Mansion House.

The first train to pass through the tunnel after the explosion was also a down train from Windsor, due at Westminster at 8.1, but running four minutes late. It was only detained about two minutes at Westminster, and so passed the scene of the explosion from three to four minutes after the latter occurred.

Character of explosion.

The explosion is described by those who heard it at Charing Cross and Westminster as having been of a sharp well-defined character, and very loud, and accompanied, at any rate at the Charing Cross end, by a considerable discharge of smoke from the mouth of the tunnel, and a smell which is described by some of the witnesses as like that of gunpowder or fireworks.*

None of the witnesses speak of having heard more than one explosion, and there is no evidence as to the explosion having been preceded (as was the case at Praed Street) by any light; but as to this it may be remarked that it is doubtful whether under the circumstances, and having regard to the curves of the line, any such light could have been observed.

Nature and quantity of explosive employed.

We now pass to the consideration of the question of the nature and quantity of the explosive employed.

The officers of the two Companies who heard the explosions seem in every instance to have supposed at the moment that they were explosions of gas.

Consideration of question whether the explosions could have been due to gas.

With few exceptions the carriages on the Underground Railway are lit with compressed oil gas made by the Pintsch process.

Pintsch's gas is a permanent gas, produced by slowly passing a mineral oil into a highly heated retort, which effects a decomposition of the hydrocarbons present in the oil.†

A cheap shale oil is usually employed. The gas, compressed for use into iron cylinders under a pressure of several atmospheres, passes to the burners through a regulator specially adapted to adjust the flow to the constantly

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* Evidence of Wm. Hext (station inspector, Charing Cross), Frederick Churchill (driver of the up train at Charing Cross), Frederick Booth (guard of ditto), Alfred Carpenter (fireman of ditto), Robert Bradley (under-guard of ditto), Wm. Bowden (driver of up train at Westminster), Wm. Bundey (guard of ditto), Edward Noble (under-guard of ditto), Alfred Tibbets (station inspector, Westminster), John Coldrey (signalman at Westminster), and others. The driver (Pawley), the guard (Lewis), and the under-guard (Jarvis) of the down train, which passed through the tunnel from three to four minutes after the explosion, speak very emphatically to the foul state of the tunnel from smoke and smell. The two guards had to put their windows up, and the guard Lewis stated that he suffered from headache in consequence. (See also second foot-note on p. 8.)

† This is not to be confounded with the so-called "air gas," made by passing air over a volatile hydro-carbon. Air gas in fact is merely air "carburetted," or charged with the vapour of "gasoline." The Pintsch gas is produced, not by the vaporisation of the hydro-carbons, but by their decomposition in contact with the red-hot retort. Although petroleum spirit or shale spirit could be used for the production of the Pintsch gas, yet as such spirit contains less carbon in proportion to its hydrogen, it would not yield so rich a gas, while the more volatile character of the spirit would tend to favour the escape of some portion of it from the retorts undecomposed.

diminishing pressure in the cylinders. We understand that the high illuminating power of the gas (about four times that of ordinary coal gas) results in a satisfactory light at a consumption of less than one cubic foot per hour, and thus the reservoirs are not required to be unduly bulky. The cylindrical reservoirs or holders in which the gas is contained are situated underneath the centre of the carriages, and contain enough gas for a consumption of about 24 hours. The first impression of eye-witnesses in each instance seems generally to have been that one of these holders had exploded. But, as a matter of fact, all the holders were absolutely uninjured; even those holders attached to the injured carriages of the Praed Street train, as already stated, were found on being tested by us to be in perfectly good order; while in the case of the trains at Charing Cross and Westminster, the fact that the gas was immediately relit showed that the gas apparatus was unaffected. Even if the holders attached to the Praed Street train had been injured (as might easily have happened in the case of the last two carriages), the suggestion that such injury was due to the gas contained therein could not have been entertained; for, independently of the extreme difficulty of producing an explosion of such a holder,* the character of the damage inflicted was not such as could be produced by gas. Moreover, neither of the craters due to the explosions was in a position in which it could have been produced by the gas used to light the trains.

For similar reasons we may dismiss the idea that the coal gas by which the stations were lit was in any way connected with the explosions.

An examination of the sites of the explosions and of the injured train at once rendered evident to anyone who is familiar with the action of explosives (1) that they could only have been produced by some form of explosive proper applied at the spots marked by the craters, (2) that the amount of explosive employed in each case must have been small.

Character of explosive.

As regards the character of the explosive, in neither case were there any indications of the action of gunpowder.†

We sought in vain on the walls, on the rails, and in the injured carriages of the Praed Street train for any of those appearances, and for that peculiar smell from the solid residue,‡ which, we believe, are always more or less distinguished in cases of explosions of gunpowder. Again, the nature of the craters (especially that which had been formed in the brickwork of the Praed Street tunnel) forbids the suggestion that the agent employed could have been gunpowder. The exceedingly local action which these craters indicate is not such as can properly be credited to gunpowder; while the finely shattered condition of the flinty ballast, added to the pulverized condition of the bricks in the Praed Street case, testify unmistakeably to the employment of an explosive of far greater rapidity and detonative energy of action than gunpowder. Even the supposition that the gunpowder may have been enclosed in a strong metal envelope would fail to meet the case, while it appears to us certain that had such an envelope been employed in conjunction with the explosive, portions of it (probably considerable portions) would have been found.

Again, the intensely shattered condition of the injured carriages; the finely divided and even powdered condition of much of the glass as recovered from the carriages and from the wounds of the patients; the peculiar fracture of the gas pipes and switch rod; the smashing up of the board on which the latter was supported; the disintegrated ends of the sleepers in the

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* Illuminating gas by itself, and unmixed with atmospheric air or oxygen, is absolutely inexplosive (see Report L., pp. 7, 8).

† We do not overlook the fact that the smell in the Charing Cross tunnel is said to have resembled that of gunpowder or fireworks; but the comparison was rather of a general than of a particular character, and was not the testimony of persons qualified by experience to distinguish accurately between the smell of one explosive and another. We understand rather that they intended to convey the impression that the smell was that of some substance of a gunpowdery (*i.e.*, explosive) character. Moreover, the smell in a tunnel of the Underground Railway, the atmosphere of which had been churned up by sharp detonation, would be one in which even an expert in such matters would have some difficulty in distinguishing the particular odours or components. Again, there can be little doubt that the smoke which was observed to issue from the tunnel at Charing Cross was the smoke of the trains ordinarily contained in the tunnels, mingled with soot and débris driven out by the explosion.

‡ Such as everyone who has ever passed his finger into the barrel of a recently fired gun must be familiar with.

Charing Cross case; the pitted woodwork and masonry; the fine particles of ballast, metal, and even pieces of string deeply embedded in the foot-boards; the exceedingly sharp sound of the Praed Street explosion, as testified to by several witnesses, and especially shown by the fracture, in some cases, of the drums of the ears of the injured persons; and generally the intensely local and, so to speak, acute character of all the observed effects, are so many converging lines of testimony to the irresistible conclusion that the explosive employed in both cases was one of the nitro-compound (or to speak more familiarly, dynamite) character.*

The same effect could doubtless have been produced by some explosives of a less well-known character, as, for example, certain of the explosives with which the name of Hermann Sprengel is generally associated. But there appears to us to be no grounds for specially inclining towards the belief that an explosive of this description was employed

But further and very direct proof is afforded on this point in the Praed Street case by the discovery by us of a considerable number of small pieces of copper deeply embedded in the under side of that part of the top foot-board of the rear third-class carriage which was immediately over the explosion. These thin pieces of copper (of which a total weight of 6·34 grains has been extracted by Dr. Dupré from the wood) prove to be clearly portions of a detonator, such as is commonly employed to effect the explosion of dynamite and other nitro-compounds.† We also discovered indications, although slight, of the employment at Praed Street of what may have been a zinc case containing the explosive.‡

The presence of an exploded detonator would by itself be almost sufficient proof that the agent employed at Praed Street was not gunpowder but was one of the nitro-compound family of explosives, and the other indications enumerated above may be accepted as conclusive as to the employment of an explosive of this class in both cases. But we have no means of ascertaining what was the exact composition and quality of the compound employed.

The quantity of explosive.

As regards the quantity of explosive employed, it would obviously be impossible to pronounce any definite opinion on this point in the absence of precise knowledge as to the composition and strength of the particular compound used. But from our general observation of the effects, and from some experiments which, with the assistance of Sir Frederick Abel, C.B., chemist to the War Department, and of Dr. Dupré, F.R.S., we have carried out in the Royal Arsenal, in which experiments we employed the identical gas-pipe and switch-rod which had been injured in the Praed Street tunnel, and under conditions as nearly as possible similar to those which are known to have existed in the tunnel, we consider that it may be safely inferred that the explosion at Praed Street was accomplished by something not much (if at all) exceeding the equivalent of 2 lbs. of ordinary dynamite properly detonated. But the observed effects, coupled with the results of our experiments, appear to indicate that the amount which actually exploded§ was

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* The possible, although not very probable, presence of some particles of the explosive, or its components, in the faces of those who were more seriously injured has not been overlooked by us. The medical officers of the hospital have, however, after most careful search been unable to discover anything which could be identified as particles of an explosive or its constituents. Our experience and some experiments which we made in regard to the possible recovery of particles of the inert ingredients of dynamite tend to show that even the minute "diatoms" which are characteristic of "kieselguhr" (the inert ingredient of dynamite) are so completely destroyed by an explosion as not to be recognisable afterwards. (See Report No. LI.) Hence the absence of any recognisable particles in the wounds of the injured persons contributes nothing positive towards a solution of the question.

† The total quantity of copper recovered (viz., 6·34 grains, as above stated) would represent about one-third the copper in an ordinary "treble" detonator.

‡ We failed to find any indications of this sort in the Charing Cross tunnel, although we sifted most diligently and examined five sacks of ballast taken up from the neighbourhood of the explosion, and we also carefully examined the pittings on the wall. But the exceedingly minute fragments into which a zinc case is liable to be blown, and the fact that a magnet will not (as with an iron case) collect these particles, render it not at all surprising that no portion of the same should be detected even by the most rigorous search. In the Praed Street case, as will presently appear, there are grounds for believing that the greater part of the case was consumed before the explosion.

§ It will be observed (p. 12) that we are of opinion that in the case of the Praed Street explosion some portion of the charge, possibly a considerable portion, burnt away without exploding, and the estimate above relates to the quantity which *exploded*, and not to the quantity originally employed.

probably somewhat in excess of 2 lbs. of a less powerful explosive than ordinary dynamite; or, if dynamite were employed, that the detonation was not of the highest order.

In the case of the Charing Cross explosion, the data on which conclusions can be based as to the quantity employed are much slighter; but if the two explosions were part of one concerted plan it would not be unreasonable to surmise that the same charges were employed in both cases, and we do not find anything in the observed effects of Charing Cross explosion which would be inconsistent with the suggestion.*

How fired.

The next point which presents itself for consideration is in what way the firing of the charges was effected.

We regret to say that the indications on this head which we have been able to obtain are mainly (and in the case of the Charing Cross explosion entirely) negative. The most diligent search of the débris collected in the tunnels, and the sifting and close examination of large quantities of ballast from the neighbourhood of the explosions,† has failed to produce anything which would enable us to solve this question satisfactorily or even approximately. The whole of the carriages of all the trains which passed that evening have been carefully searched, and we have letters and evidence from the different railway companies concerned to the effect that nothing was found of a suspicious character or tending to show in what way the explosion in either case was brought about. It is, we think, probable that the particular arrangement employed at the Glasgow explosions of January last,‡ and which was found also in connection with the infernal machines seized last spring at Liverpool, was not employed. We infer this from the following considerations:—The arrangement consisted of a brass tube fitted with a tap, by means of which sulphuric acid could be allowed to flow on to a mixture of chlorate of potash and sugar (with or without red orpiment), the time of action being regulated by folds of paper or other suitable substance, through which the acid would eat its way to the chlorate mixture after a calculated interval of time. Directly the acid came into contact with the chlorate mixture brisk ignition would ensue. Now, in the first place, such an arrangement would certainly not be a convenient one, or even practicable without special adaptation, if the infernal machine were to be thrown from a train, while the fact that nothing of the nature of the brass tubes used in the before-mentioned cases or any part thereof was found§ tends also to show that this particular arrangement was not employed.‖

But it does not follow that the agency of acid was not taken advantage of to effect these explosions. If the acid were employed in the well-known form in which it was for many years applied to the "Coast Guard Portfire," viz., enclosed in a glass globule embedded in a chlorate mixture,¶ it is improbable that any portions of the apparatus would be recovered, while such an arrangement, by at once avoiding all risk of the spilling of the acid, and by securing ignition by the fall of the machine, would be adapted for use under these circumstances. A small piece of steel weighing four grains was found embedded for its own length ($\frac{7}{8}$ inch) in the under side of the fore

* But as there are no indications in the Charing Cross case of any of the explosive having burnt away without explosion, it would follow that the amount which exploded at that point was probably greater than the amount which exploded at Praed Street by the quantity which in the latter case burnt away without exploding.

† At Praed Street the whole of the ballast in the tunnel to a depth of 2 inches was taken up and sifted or examined in our presence, while the whole of the ballast at and about the crater was sifted and searched with a powerful magnet. In the Charing Cross case five large sacks of ballast collected from the tunnel were treated in the same way.

‡ See Report No. L., 14th March 1883, p. 20. See also Report No. LI., 17th April 1883, pp. 8, 9.

§ One minute piece of sheet brass was found. It was among the débris dug out of the Praed Street crater, and was firmly wedged into a small piece of iron (? piece of gas-pipe) which was recovered from the crater by means of a magnet. We are unable to identify this piece of brass (which weighs only 0·210 grains) with any part of a brass tube, such as was used at Glasgow, and had been supplied in connexion with the Liverpool infernal machines.

‖ Taken by itself, the non-finding of portions of the tubes would hardly perhaps be conclusive. Thus it is by no means certain that such an arrangement was not employed at the Local Government Board explosion in March 1883, though no part of the same was found (Report No. LI., 27th April 1883, p. 8). On the other hand, a portion of such an arrangement was found after the Glasgow Gasworks explosion (Report No. L., 14th March 1883, p. 17), where the explosion had been violent.

¶ Treatise on Ammunition. 1st Edition, pp. 215–216.

end of the near footboard of the last third-class carriage (*i.e.*, immediately over the explosion). It appears to have formed a portion of a fine tube, but its small size renders it impossible to say what function, if any, it was designed to discharge in relation to the firing of the explosive.

But any arrangement for establishing ignition by concussion, whether derived from the chemical action of sulphuric acid on a chlorate mixture, or by the release of a spring, or by one of the very many modes by which it could be accomplished, would obviously necessitate the employment of some intermediate fuze or contrivance to establish a sufficient interval between the first ignition and the explosion for the operator to escape. Failing such contrivance the operator would clearly be exposing himself to the gravest risk. In the Charing Cross case nothing of the nature of a fuse or contrivance adapted for producing a retarded action was found; but in the Praed Street case our search of the ballast from the surface of the tunnel was rewarded by the discovery of a piece of unfired ordinary safety blasting fuze, of Messrs. Bickford, Smith, and Co.'s make,* about 7 in. long, and having the two ends broken and unravelled, as if torn violently asunder. It is of course not absolutely certain that this piece of fuze was connected with the explosion; but as blasting operations are not carried on upon this line, fuze is not required by any of the workpeople; while London not being the centre of a mining district such fuze is not greatly in use in the neighbourhood. Accordingly, it is not such an article as would be likely to be dropped by a workman or miner or other passenger from a train, and we were given to understand that there is no other instance of any piece of such fuze having been previously found in one of the tunnels.

On the other hand, this piece of fuze had evidently not lain for any long period in the tunnel; and it would certainly be a most remarkable (although not strictly impossible) coincidence that the only instance of the discovery of a piece of such fuze should be immediately after an explosion, and in the particular short length of tunnel in which that explosion occurred, unless the fuze had been in some way connected with that explosion.†

And its probable connection with the explosion is not, we think, difficult to conjecture. If one end of the fuze were in connection with the igniting arrangement (of whatever description) and the other end were fitted to the detonator, the operator would secure for his escape the interval of time due to the burning of the length of fuze, which at the normal rate of burning would for a piece 7 inches long be not less than about 13 seconds.‡ Such a retardation in the case of a machine dropped from an ordinary train in rapid motion would suffice to clear that particular train, which is all that would be necessary to enable the operator to effect his escape.

But it will be at once objected that as in this case the fuze, being unburnt, had evidently not acted, it is impossible that it could have played the part suggested in this particular explosion. This brings us to a point of considerable importance. We have mentioned that we found a portion of the under side of the train, from about the centre of the first-class carriage to the point of explosion, marked with white splashes or flecks.§ These marks have all the appearance of having been caused by the spluttering from some burning body underneath this portion of the train, which burning had obviously (as is shown by the abrupt cessation of the splashing at the point of explosion) ceased when the explosion occurred. We have the further and decided testimony of several witnesses to the existence of a very bright light on the left side of the train for some seconds previous to the explosion.‖ It seems impossible to doubt that these splashes and the bright light were due to the burning of the same substance. A careful examination of these

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* The various makers have special trade marks by which the fuzes made in their respective factories can be identified.

† We do not overlook the fact that the fuze may have been thrown out of the train subsequent to the explosion, by some person who was mischievously disposed to introduce a disturbing element into the factors at the disposal of those on whom the investigation of this explosion devolves.

‡ One yard of perfect fuze burns from 65 to 72 seconds.

§ See p. 6.

‖ See p. 6. The peculiarly bright character of the light seems to have attracted particular attention. One witness (Joseph Double) when asked by us to describe it appeared to consider that, though not so bright as the electric light, it could be more fitly compared in this respect to the electric light than with any other.

splashes by Dr. Dupré has disclosed the fact that although consisting mainly of whitewash (doubtless from the walls of the tunnel) they contained a small but distinctly recognizable quantity of zinc,* a circumstance which not only furnishes a probable explanation of the remarkable brightness of the light, but suggests that the light was almost certainly due to the burning of the explosive contained in or otherwise in contact with zinc. We have, in conjunction with Sir Frederick Abel and Dr. Dupré, carried out an experiment on this point, and we find that one pound of dynamite wrapped in sheet zinc of moderate thickness burnt with sufficient energy (and without explosion) to consume the greater part of the zinc envelope.

Further corroboration of the view that the explosive was probably contained in or was in contact with zinc is furnished by the discovery by Dr. Dupré on the rear spring of the first third-class carriage (*a*) on the near side (*i.e.*, towards the explosion) of a small piece of zinc, which had apparently been splashed against the spring in a melted state.

We have already mentioned the finding in the under side of the top footboard of the rear third-class carriage of a number of pieces of copper, which had evidently formed part of a detonator such as is used to explode dynamite. It is also noteworthy that from the under side of the rear end of the middle third-class carriage on the near side (*i.e.*, almost over the point of explosion) several fragments of fibres, like torn pieces of string (and not forming portions of a fuze) were obtained. These bits of string were driven into the board with great violence, having penetrated in one case half an inch into the wood, and must therefore have been very close to the focus of explosion.

All these various circumstances taken together seem to suggest a reasonable theory as to what actually occurred in the case of the Praed Street explosion. It is, we think, probable that some miscarriage occurred in the igniting of the charge, and that by some mischance the explosive itself became ignited during the passing of the train, the fuze having somehow failed to act and become violently detached. The ignited explosive continued to burn energetically,† and with the exceptional brilliancy due to the zinc present in the apparatus, until it reached the detonator, the explosion of which detonated the unconsumed portion of the charge exactly as the fore portion of the rear third-class carriage was opposite to it, with the effects described.

This hypothesis appears to fit in with all the observed results in a way that every other explanation which occurs to us fails to do. It accounts at once for the presence and position of the splashes, for the zinc contained in them, for the bright light preceding the explosion and its remarkable intensity, for the recovery of an unburnt piece of fuze, and for the ultimate explosion; and, as we shall see further on, it coincides with some other probabilities. We venture therefore to submit this explanation with considerable confidence.

In the Charing Cross case there is nothing to suggest that any miscarriage occurred in the explosion of the machine; and the non-discovery in that case of any fuze or of any zinc, coupled with the absence of all indication on the walls or otherwise of the burning of any portion of the explosive or case, would of course be perfectly consistent with the correct action of the apparatus and the complete detonation of the charge.

How were the charges deposited in the tunnels?

Three possible modes.

First possible mode of introducing charges into tunnel.

The only point remaining for examination is how the charges became deposited in the tunnels.

There would appear to have been only three possible ways by which this could be effected:—

(*a*) By carrying the charges into the tunnels and depositing them by hand, (*b*) by dropping the charges through ventilators or other openings, (*c*) by dropping the charges from trains in motion.

As regards the first of these, we may observe that it seems hardly necessary to argue that the presence of the explosive in the tunnels must be referred to a deliberate and doubtless malicious design. And having regard to the

* The whitewash from the tunnel walls did not contain any zinc.

† It is a well-known fact that dynamite and similar nitro-glycerine preparations may be burnt under certain conditions and in small quantities without exploding. See, for example, the experiments mentioned in text above.

synchronism of the two explosions, and to all the corresponding circumstances attending them, as well as other explosions and attempts which we have recently been required to investigate, it would appear unreasonable to suppose that these outrages were not animated by the same intention, or to suggest that they did not form part of one scheme or plot.

It appears to have been the intention of the authors to produce explosions on the Inner Circle of the Underground Railway at points as nearly as possible opposite to one another, and as nearly as might be at the same time. We venture to think that in seeking for the best means of accomplishing this, with the greatest certainty and the least risk of interruption or detection, it would naturally occur to those engaged that the best method would be to start from two given stations at a given time or times, and throw the infernal machines out of the window. It could hardly fail to suggest itself that by this means that coincidence in point of time which it was evidently one of the objects of those engaged in the enterprise to secure would be more easily and surely attained than by making incursions into tunnels in order to deposit the machines therein. We have satisfied ourselves by careful inquiry that it would under no circumstances be a very easy thing for a man to penetrate into either the Praed Street or Charing Cross tunnels unobserved; and owing to the special vigilance which we found had for some months past been exercised by the railway authorities in this direction, the normal difficulties of entry may be regarded as having recently been considerably enhanced.* For two men to attempt to pass into the tunnels, one into each, would be to double the risk; while the chances of both men accomplishing this object at an identical or nearly identical moment of time would obviously be exceedingly remote.

These are considerations of so elementary a character that they could hardly escape those who had undertaken the solution of the problem which we have described. A little reflection would also serve to show that the arguments against depositing the explosive in the tunnels by hand did not stop here. There was not only the getting into the tunnels—there was the getting out of them. And there was not only the getting out of the tunnels but the rapid withdrawal from the scenes of action to some place of comparative safety in relation both to the explosive effects and to the possibilities of detection. Further, the risk in the tunnels from passing trains to a stranger unprovided with a light would constitute a very appreciable and independent danger. If it could be supposed that these considerations would not have had sufficient weight to deter any men of the most ordinary intelligence from attempting to accomplish their design in this way, it may be asked why in the Charing Cross case did they take the trouble to select one of the longest tunnels on the line, and to penetrate 241 yards therein before depositing the charge. If a position only 46 yards from a tunnel's mouth would suffice at Praed Street why not at Charing Cross? From the point of view of creating public alarm a position near a station would appear to be more likely to be effective than one more remote, where the sound and consequences would be less apparent. On the other hand, if the object were specifically to do more than create public alarm, it seems to us that the perpetrators of the outrage, if they had had the command of the place of deposit (as would have been the case with persons walking into the tunnels and depositing the charges by hand), would probably not have selected the particular spots and methods of attack which were selected in these cases.

We venture therefore to dismiss as in the highest degree improbable the suggestion that the charges were carried into the tunnels and deposited by hand.†

This leaves two possible modes of introduction, viz.:—The dropping of the charge through a ventilator or other opening; secondly, the throwing or dropping of the charge from a train.

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* As testifying to the vigilance with which this observation was exercised, evidence was laid before us to show that even servants of the Company having business in the tunnels have been challenged by the signalmen stationed near the entrances.

† It may be worth while to place on record that we have diligently inquired of everyone who would have been likely to see anyone enter or leave either of the tunnels—signalmen, station inspectors, platform porters, drivers and guards of the trains immediately preceding and following the explosions; and no one of these witnesses saw anyone enter or leave either tunnel on the evening in question.

Second possible method of introducing charges into tunnel.

As regards the former of these methods, it is to be observed that there is no ventilator or other opening over the spot where either of the charges exploded. In both cases the train had shortly before passed under openings (protected by high walls), in the Praed Street case at either end of the station (distant respectively 152 yards and 37½ yards from the explosion), in the Charing Cross case under a ventilator in the Embankment Gardens (distant 63 yards from the explosion). An infernal machine dropped on to a passing train through either of the openings might have been conveyed for a little distance and then rolled off to one side or other of the train. But this mode of attack, while possessing certain not inconsiderable physical difficulties, and involving rather an inconveniently large risk of detection, appears to offer no advantages, and we can see no reason whatever for assigning to it any high degree of probability.

Third possible method of introducing charges into the tunnels.

On the other hand, the plan of throwing or dropping the charge from a train appears to recommend itself by several considerations.

In the first place, it was the plan which offered the greatest chance of effecting two explosions at remote points as nearly as possible simultaneously. In the next place, it solves in the simplest possible manner the difficulty of getting into the tunnels. In the third place, it solves in a peculiarly convenient way the not less important problem of getting out of the tunnel unobserved. Fourthly, it places the operator in the very advantageous position of being in process of rapid conveyance from the scene of explosion even before the charge touched the ground. Lastly, it gives him a choice of any of the numerous stations on the Underground Railway from which to effect his exit, and probably before the fact of an explosion having occurred could become known at some of those stations.*

It has been suggested that as this plan of operation might involve personal risk to those actually concerned, it is unlikely to have been resorted to. As a matter of fact, however, the plan did not necessarily involve any risk whatever. Besides, it is not to be supposed that men who were doubtless familiar with the conveyance by Whitehead and his associates of large quantities of liquid (and not very pure) nitro-glycerine in waterproof bags and fishing stockings from Birmingham to London, would have hesitated to drop a charge of dynamite judiciously arranged from a train in motion. Certainly if they had been disposed to weigh the degrees of personal risk attending the various methods, they could hardly have resisted the conclusion that of those methods the plan of dropping the explosive from a train offered on the whole by far the larger margin of safety, not merely in regard to possible personal injury, but also in the material matter of escape from detection.

We have indicated the grounds on which we believe that the charge exploded prematurely in the Praed Street case; but even in that case it will be observed that another second or two would have cleared the train. It may, we think, safely be concluded that the actual perpetrator of the Praed Street outrage did in fact escape personal injury, for he must have been in front of that part of the train where the splashes began, viz., the centre of the first-class carriage, and no injury (except one broken window) was occasioned to the train in advance of this point; while in the Charing Cross case the up train, as we have seen, had preceded the explosion by over a minute, and sustained no injury whatever. In short, it would appear certain that in both instances (notwithstanding the Praed Street mischance) the actual perpetrators must have got off without injury. However this may be, we cannot doubt that if those who were concerned in these outrages were to have been influenced by considerations of personal risk, the last plan which they would have been likely to have resorted to would have been the almost desperate expedient, as it would appear, of entering the tunnels on foot.

Frequency of empty compartments.

It has been suggested that it might be difficult for two operators to be able to count upon the probability of being able to secure an empty compartment from which to carry on their operations. Apart from the consideration that (unless the fuze had to be lighted by means of a match or

* For example, it appears that, as before stated, no one in the last down train which passed through the Charing Cross tunnel before the explosion, and which could only have cleared the tunnel about a minute, know anything of any explosion having occurred until the train reached the Mansion House.

similar agent, which would be an unlikely and very clumsy mode of procedure,) an empty compartment would not be necessary to the successful carrying out of the simple operation of dropping a parcel from a train without attracting attention,* there is the fact that empty compartments are by no means difficult to find. We satisfied ourselves by inquiry that it is by no means difficult to find an empty compartment (especially in a first or second class carriage) on an up train in the evening, from about 7.30 p.m. to 9 p.m.

Lord Sackville Cecil was good enough, at our request, to have observations made of the number of empty compartments in the up trains passing through Charing Cross station between 7.30 p.m. and 8.30 p.m., from Friday, 2nd November 1883, to Thursday, 8th November 1883.

The results are given in the following table :—

Date.	No of Trains	No. of Empty Compartments			Average per Train.		
		1st Class	2nd Class.	3rd Class.	1st Class.	2nd Class.	3rd Class.
Friday, 2nd Nov. -	16	44	27	5	2·75	1·69	0·31
Saturday, 3rd „ -	16	65	58	53	4·06	3·62	3·31
Sunday, 4th „ -	12	76	65	77	6·33	5 42	6·42
Monday, 5th „ -	16	35	29	5	2·19	1·81	0·31
Tuesday, 6th „ -	16	16	34	7	2·88	2·12	0·44
Wednesday, 7th „ -	16	47	26	9	2·94	1·63	0·56
Thursday, 8th „ -	16	39	28	12	2·44	1·75	0·75
	108	352	267	168	3·26	2·47	1·56

Even allowing for the traffic having been heavier during the Fisheries Exhibition than it has been since the close of that Exhibition on 31st October, this leaves a sufficient margin for conspirators to reckon upon with reasonable certainty. It appears from our inquiries that the up trains on the evening of the 30th October about the time of the explosion were not exceptionally full, and the under-guard of the up train which immediately preceded the explosion in the Charing Cross tunnel speaks positively to at least two compartments having been empty nearly the whole run.

Probability as to particular trains from which explosives thrown.

It may be interesting to consider the probability of the charges having been thrown from the trains respectively nearest to the explosions, *i.e.*, in the Praed Street case the injured train, and in the Charing Cross case the train which was just leaving Westminster at the time of the explosion. It is to be observed that no material advantage in point of safety to the operator would be derived from the use of a longer fuze than would suffice to clear the train from which the charge was to be thrown, and this could be accomplished by a fuze which would retard the action even by a few seconds.

On the Praed Street portion of the line the up trains run at intervals of 10 minutes. Accordingly, if the charge had been thrown from a preceding train to that which was injured, the fuze must have burnt at least 10 minutes. To suppose that this actually occurred involves the assumption either (*a*) that a wholly unnecessary and very inconvenient length of fuze or slowing arrangement had been deliberately adopted, or (*b*) that the action, instead of having been premature, as we have suggested, was in fact from some cause or other unduly prolonged, in addition to having been unexpected in regard to the burning of a portion of the charge.

* The evidence as to the very remarkable and miscellaneous character of the articles found by the scavengers in the tunnels is conclusive as to its being quite a common thing to throw parcels and packets of various sizes out of the windows. We ourselves found in the Praed Street tunnel a parcel (or the remains of one) far larger than a parcel containing a few pounds of dynamite.

Against the first of these assumptions we would present not merely its intrinsic improbability, but the fact that a totally different arrangement must in that case have been adopted at Praed Street to that which was employed at Westminster (unless it was there intended that several trains should pass between the laying of the charge and the explosion*), while if the slowing arrangement consisted of safety blasting fuze like the piece that was found, no less a quantity than about 30 feet of such fuze would have had to be employed, largely increasing the bulk of the package, and multiplying the risk of failure. Had any such length been used it is almost certain that some considerable remains of fuze would have been recovered.

As regards assumption (*b*) the evidences of the burning of some of the explosive before detonation, and the fact that a piece of fuze was discovered unconsumed, but injured apparently by some violent rending force, seems to point unmistakeably to the action having proceeded prematurely, as we have suggested, rather than to any abnormal retardation having occurred.†

And if we conclude that the Praed Street charge was intended to act shortly after the train from which it was thrown had cleared, it is reasonable to suppose that the same intention prevailed in the Charing Cross case, where, as a matter of fact, we find that the charge exploded from one to two minutes after a train had passed the spot.

Summary of conclusions as to circumstances attending the explosions.

Summing up, we beg to express our opinion (*a*) that the explosions were maliciously and deliberately effected in each case by a charge of some explosive of the nitro-compound (or as it is more commonly called dynamite) character; (*b*) that the charge did not in either case exceed a few pounds, and (unless an exceptionally weak nitro-compound were employed) may in both cases be confidently set down as under 5 lbs.; (*c*) that the charge was in each case dropped or thrown from an up train, viz., in the Praed Street case from the injured train, and in the Charing Cross case from the up train which was just leaving Westminster when the explosion occurred; (*d*) that the charge in the Praed Street case exploded prematurely, the fuze or arrangement on which the retardation of the action was to depend having failed to act as intended, a portion of the charge being burnt and the remainder exploded before the train was clear.

We should, we conceive, be going beyond the scope of our proper duties were we to attempt to speculate on the precise objects and the exact amount of destruction which the conspirators proposed to effect by these outrages. In the absence of definite information as to the perpetrators, this portion of the inquiry appears to us to belong more strictly to the police. But the facts which we have collected and the conclusions which we have drawn may not be without their use in assisting those on whom the duty devolves of discovering and bringing to justice the perpetrators of what we will permit ourselves to stigmatise as a most atrocious outrage,—one which has not only caused suffering and serious alarm to a large number of innocent persons, but which narrowly escaped producing consequences of a far more disastrous and fatal character.

It would be affectation to pretend that we can regard this outrage as distinct from others which have been recently carried out or attempted at Glasgow, in London, and elsewhere. But if anything were needed to establish

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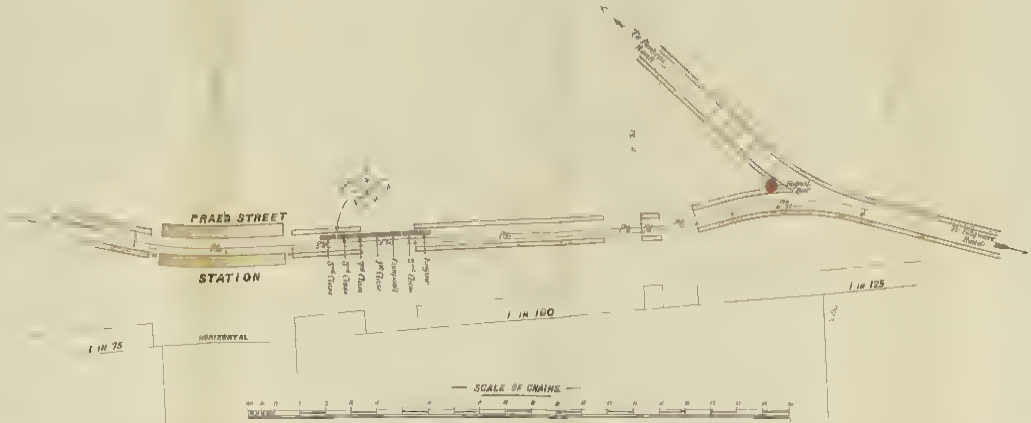
* The up service on this section is about a three-minute service.

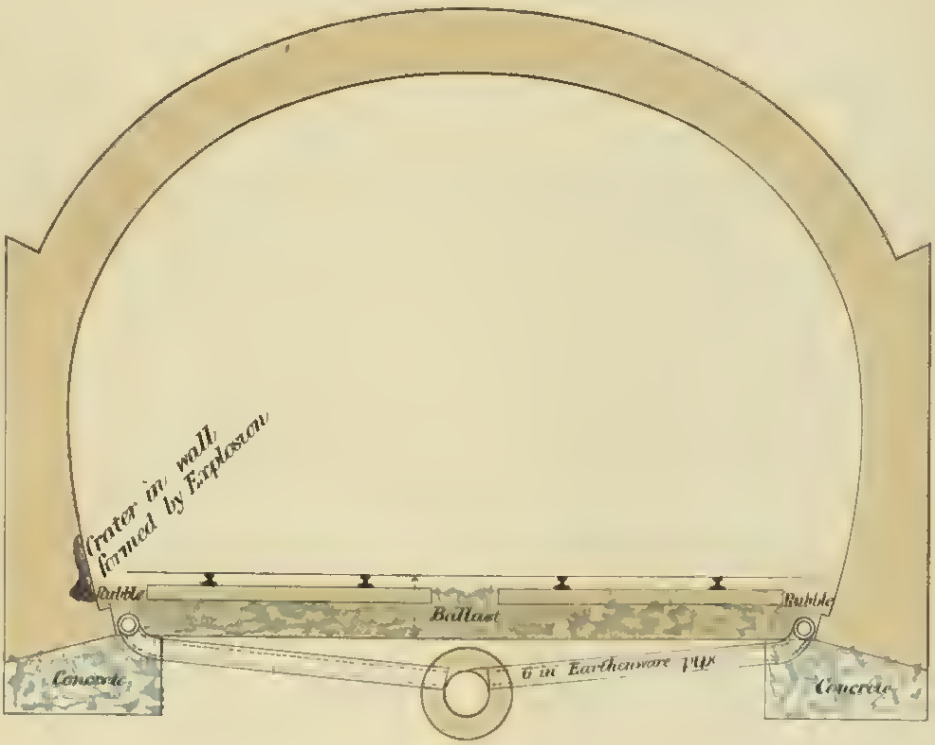
† An intelligent witness, Mr. W. J. Langridge, who was travelling in the rear compartment of the first-class carriage, is very positive that he heard two explosions, with an appreciable interval of time between. The first explosion, which was coincident with the sudden appearance of the bright light which preceded the larger explosion, he describes as having been like a fog-signal going off. He is the only witness who heard a double explosion, and although we are not prepared positively to say that he was mistaken, and that the first explosion was not due to the action of some part of the apparatus, we think that this first "explosion" may very well have been the sharp slamming of a door. We have carried out some experiments on this point, and the violent slamming of a carriage door in a tunnel sounds remarkably like the explosion of a fog-signal. It is, perhaps, permissible to conjecture that the person who had thrown out the infernal machine, and who may have opened the door to enable him to place it down with as little shock as possible, on seeing that the explosive had taken fire and would therefore shortly explode, instinctively shut the door again with great energy, thus producing the sound which Mr. Langridge thinks was an initial explosion.

METROPOLITAN RAILWAY



METROPOLITAN RAILWAY.

SECTION OF TUNNEL ADJOINING PRAED ST. STATION.



SCALE OF 5 FEET TO ONE INCH

DANGERFIELD LITH. 22 BEL[illegible]RD ST COVENT GARDEN 6781

DISTRICT RAILWAY

Plan of Line between Westminster and Charing Cross

October 1883

DISTRICT RAILWAY.

LINE BETWEEN WESTMINSTER AND CHARING CROSS

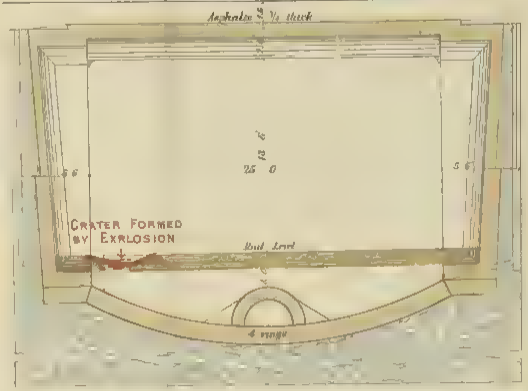
OCTOBER 1883

LONGITUDIRAL SECTION

Level of Centre of Embankment roadway

TRANSVERSE SECTION

Level of Centre of Embankments roadway



SCALE 1 FEET TO ONE INCH

the connection, the link, as it seems to us, would be supplied by the savage disregard for life, and indifference as to the consequences to wholly innocent persons, which is one of the most distinctive and abominable features of the whole series.

It is proper that we should acknowledge the very valuable and untiring assistance rendered to us by all the officers and servants of the two railway companies immediately concerned with whom we have come into contact; and among those to whose exertions and active co-operation in the object of our inquiry we are specially indebted we desire to mention Lord Sackville Cecil, general manager, and Mr. Estall, the engineer, of the Metropolitan District Railway, and Mr. Bell, general manager of the Metropolitan Railway, and Mr. Tomlinson, engineer to that Company. Sir Frederick Abel, C.B., obligingly afforded us the opportunity of carrying out in the Royal Arsenal some experiments which had an important bearing upon our conclusions, and has rendered us other and useful assistance; while to Dr. Dupré, F.R.S., we owe on this, as on many former occasions, our warmest thanks, not merely for the very careful chemical and other examinations which he has conducted, but for the numerous and very valuable suggestions which he made to us throughout the inquiry.

We have the honour to be,
Sir,
Your obedient servants,
V. D. Majendie, Colonel,
H.M. Chief Inspector of Explosives;
J. P. Cundill, Captain, R.A.,
H.M. Inspector of Explosives.

The Right Hon. the Secretary of State,
Home Department.

APPENDIX A.

Metropolitan Railway, Engineer's Office.

The following damage was done to Praed Street station by an explosion in the tunnel last night:—

Four large plate-glass windows on gallery front of refreshment rooms, all the glass broken.

One square of plate-glass in fan-light over doorway leading to gallery from booking-office lobby broken.

Two squares of plate glass in window on inlet stairs to "up" platform broken.

Two large plate-glass windows in booking office, all glass broken

Seven squares of Hartley's glass in roof broken, and the remainder very much shaken from concussion.

All the glass in the signal-box broken.

October 31st, 1883

APPENDIX B.

METROPOLITAN RAILWAY.

PARTICULARS of DAMAGE to TRAIN that was passing through the Tunnel at the time of the Explosion near Praed Street Station on the evening of the 30th October 1883.

No. 224, *third-class coach*.—3 partitions broken; 3 intermediate partitions displaced; 2 doors smashed; cross framing and heads on 2 doors broken; inside lining boards broken; upside cornice roof board and roofing canvas broken; 8 end panels broken, 33 body and door panels broken; 9 standing and 3 intermediate light pillars broken; 31 quarter-lights, 17 top lights, 1 top foot-board, 1 bottom foot-board, 1 step-iron, 2 roof lamps, 6 lamp reflectors, and 6 roof lamp globes broken; and 2 step-irons bent.

No. 36, *third-class coach*.—Break end of coach entirely smashed; floors in 7 compartments displaced; 3 partitions, roof boards and canvas, 15 quarter and door panels, half the framing on "up" side of body, hoop sticks, 25 quarter-lights, 17 top quarter-lights, 11 door windows and frames, 1 door window, 1 top foot-board, 6 gas reflectors, and 4 gas globes broken; 5 doors smashed; half the roof displaced; lamp tops more or less damaged; tail-lamps and fittings damaged and missing.

No. 233, *third-class coach*.—2 partitions, 3 end panels, 4 quarter-lights, and 2 gas reflectors broken.

No. 46, *first-class coach*.—2 door glasses and 1 side panel broken.

No. 176, *composite coach*.—No defects.

No. 51, *second-class coach*.—Ditto.

APPENDIX C.

DISTRICT RAILWAY.

EXPLOSION between CHARING CROSS and WESTMINSTER, 30th October 1883.

LIST OF DAMAGE DONE.

Charing Cross Station.

Ticket sorting office.—Four squares of plate glass broken.

Waiting room.—One square of plate glass broken.

Way out stairs, up side.—Two squares of plate glass broken. One sash-frame blown partly out.

Way out stairs, down side.—Two squares of plate glass broken. Door lock broken off

Westminster Station.

Signal-box.—Four squares of crown glass broken. Door lock broken off. Two platform globular lamps broken.

Between the two stations about 60 yards of telegraph and telephone cables and wires blown off the walls, together with the wood boxing in which they were carried.

(Signed) S. A. CECIL.

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For Her Majesty's Stationery Office.